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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/502,729	02/11/2000	Stephan Alan Cohen	YO999-573	5596

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EXAMINER	
LOUIE, WAI SING	
ART UNIT	**PAPER NUMBER**
2814	

DATE MAILED: 11/24/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/502,729	COHEN ET AL.	
	Examin r	Art Unit	
	Wai-Sing Louie	2814	

-- The MAILING DATE of this communicati n appears on th cov r she t with th correspond nce address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *30 July 2003* .

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-16* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-16* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 1-6 and 8-10 are rejected under 35 U.S.C. 103(a) as being unpatentable over Li et al. (US 2002/0020919) in view of Hao et al. (US 5,939,763) and Chooi et al. (US 6,436,824).

With regard to claims 1-4, Li et al. disclose a diffusion barrier layer ([0020] to [0029] and fig. 2) for semiconductor devices having an upper surface and a lower surface and a central portion and comprising

- Li et al. disclose the silicon, carbon, nitrogen, and hydrogen compound has a lower dielectric constant than silicon nitride ([0025]);
- Silicon, carbon, nitrogen, and hydrogen ([0024]). Li et al. teach the conductive material 32 should be surrounded by nitride to prevent diffusion of Cu into insulative material 40 and oxygen into Cu layer 32 ([0012] and fig. 2) and Li et al. also teach the composition of $(CH_3)_xSi_3N_{(4-x)}$ within the barrier layer 100 ([0028]), but Li et al. do not disclose the nitrogen being non-uniformly distributed throughout the diffusion barrier layer 100. However, Hao et al. disclose ultra-thin

dielectric layer 10, where the nitrogen concentration is elevated at the thin upper and thin lower surface regions and the nitrogen concentration is low (devoid) in the center portion of layer 10 (Hao col. 6, lines 40-67 and fig. 2a-d). Hao et al. teach the nitrogen rich region is impede impurity diffusion from the gate electrode and relax the interfacial strain between the substrate and the dielectric layer 10 (Hao col. 2, lines 25-31). Therefore, it would have been obvious to one with ordinary skill in the art to modify Li's device with the teaching of Hao et al. to include a non-uniform nitrogen distributed barrier layer with a central portion is substantially devoid of nitrogen in order to have a diffusion barrier to prevent the diffusion of impurity and relax the interfacial strain;

- Li et al. disclose the silicon, carbon, nitrogen, and hydrogen compound as diffusion barrier layer ([0026]), but do not disclose the thickness of the barrier layer. However, Hao et al. disclose the thickness of the nitrogen-rich diffusion layer has a thickness of 90 Å (Hao col. 7, lines 59-63). Therefore, it would have been obvious for the one with ordinary skill in the art that the nitrogen-rich diffusion layer should have a thickness of about 90 Å in Li's device as recommended by Hao et al.

With regard to claim 5, Li et al., modified by Hao et al. in claim 1 above, would discloses the silicon oxynitride layer 10, which contained oxygen (Hao col. 6, lines 40-45).

Claim 6 is rejected under 35 U.S.C. 103(a) as being unpatentable over Li et al. (US 2002/0020919) modified by Hao et al. (US 5,939,763) and Chooi et al. (US 6,436,824) as applied to claim 1 above, and further in view of Balog et al. (US 4,123,571).

With regard to claim 6, Li et al. do not disclose the carbon and silicon in the layer is in the form of silicon carbide. However, it is well known in the art to deposit SiC by reacting silicon containing gas with carbon (methane) containing gas such as disclosed by Balog et al. (Balog col. 2, lines 45-59). Therefore, it would have been obvious for the one with ordinary skill in the art to form silicon carbide in the dielectric layer in Li's device.

Claims 7 and 11-16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ngo et al. (US 6,228,761) in view of Li et al. (US 2002/0020919) and Hao et al. (US 5,939,763).

With regard to claims 7-11, Ngo et al. disclose a semiconductor device (col. 4, line 35 to col. 6, line 48 and fig. 10) comprising:

- A substrate 40 containing conductive elements (col. 4, lines 58-60);
- A diffusion barrier layer 56 applied to at least a portion of the substrate in contact with the conductive metal 58 (col. 6, lines 19-25). Ngo et al. do not disclose the diffusion barrier layer 56 having an upper and a lower surfaces and a central portion comprising silicon, carbon, nitrogen, and hydrogen with nitrogen being non-uniformly distributed throughout the diffusion barrier layer 56. However, Li et al. modified by Hao et al., in claim 1 above, disclose the above-mentioned layers. Li et al. teach the

silicon chemically bonded oxynitride and organic material would provide a barrier between the conductive metal and insulative material to prevent the diffusion of elements (Li [0021] and [0025]). Therefore, it would have been obvious to one with ordinary skill in the art to modify Ngo's device with the teaching of Li et al. and Hao et al. to provide the diffusion barrier layer having an upper and a lower surfaces and a central portion devoid of nitrogen. Doing so would prevent the diffusion of elements and damage the device;

- Ngo et al. do not disclose the nitrogen-rich diffusion layer has a thickness between 5 to 120 nm. However, Li et al. modified by Hao et al., in claim 1 above, disclose the nitrogen-rich diffusion layer should have a thickness of 90 Å;
- Ngo et al. do not disclose the nitrogen-rich diffusion layer processing a low dielectric constant. However, Li et al. modified by Hao et al., in claim 1 above, disclose the nitrogen-rich diffusion layer has a relative low dielectric constant of 3-6.5.

With regard to claim 12, Ngo et al. disclose the conductive element is made from tungsten (col. 6, line 29).

With regard to claim 13, Ngo et al. disclose the conductive element is made from tungsten (col. 6, line 29), but do not disclose the conductive elements are made from copper. However, Li et al. disclose copper is used in the conductive layer. Since copper is a common conductive material and is a better conductive material. Therefore, it is obvious that to use copper to obtain above advantage.

With regard to claims 14-15, Ngo et al. modified by Hao et al. in claim 7 above, would disclose the thickness of the ultra-thin silicon oxynitride layer 10 is about 6 nm (Hao col. 3, lines 48-60). Since the applicant has not established the criticality of the thickness stated and since the thickness is in commonly use in similar devices in the art, it would have been obvious to one of ordinary skill in the art to use these value in the device of the thickness. Where patentability is said to be based upon particular chosen dimension or upon another variable recited in a claim, the applicant must show that the chosen dimensions are critical. In re Woodruff, 919 F2d 1575, 1578, 16 USPQ2d 1934, 1936 (Fed. Cir. 1990).

With regard to claim 16, Ngo et al. do not disclose a portion of carbon and silicon is in form of silicon carbide. However, Li et al. disclose in claim 6 above that silicon carbide could be formed.

Response to Arguments

Applicant's arguments filed 7/30/03 have been fully considered:

- Applicant's arguments that Hao et al. do not disclose the thickness of the diffusion barrier is in between 5 to 120 nm. However, Hao et al. disclose a thickness of 9 nm (see claim 1 above) and that meets the claim limitation.
- Applicant argues that Hao et al. do not disclose or teach the diffusion barrier layer has a low dielectric constant. However, Li et al. teach the diffusion barrier has a dielectric constant lower than the silicon nitride and Chooi et al. product a diffusion barrier, by reacting the methylsilane with

ammonia as disclosed by Li et al., would have a low dielectric constant of 3-6.5 (see the reasoning in claim 1 above).

Conclusion

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Wai-Sing Louie whose telephone number is (703) 305-0474. The examiner can normally be reached on 7:30 AM to 4:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Wael Fahmy can be reached on (703) 308-4918. The fax phone numbers for the organization where this application or proceeding is assigned are (703) 308-7722 for regular communications and (703) 308-7722 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0956.

LONG PHAM
PRIMARY EXAMINER

wsl
November 15, 2003